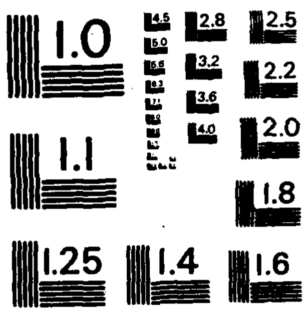
AD A136 316 THE AI RESEARCH ENVIRONMENT AT THE UNITED STATES ARMY ENGINEER TOPOGRAPHIC LABORATORIES(U) ARMY ENGINEER TOPOGRAPHIC LABS FORT BELVOIR VA R D LEIGHTY APR 83 1/1

UNCLASSIFIED F/G 8/2 NL

END
DATE
FILMED
1 84
DTIC



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER	2. GOVT ACCESSION NO.
3. RECIPIENT'S CATALOG NUMBER	
4. TITLE (and Subtitle) The AI Research Environment at the U.S. Army Engineer Topographic Laboratories	5. TYPE OF REPORT & PERIOD COVERED
	6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Dr. Robert D. Leighty	8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS US Army Engineer Topographic Laboratories Fort Belvoir, VA 22060	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS US Army Engineer Topographic Laboratories Ft. Belvoir, VA 22060	12. REPORT DATE April 1983
	13. NUMBER OF PAGES
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)	15. SECURITY CLASS. (of this report)
	15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release;
distribution unlimited

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

AI research
Center for Artificial Intelligence

DTIC ELECTE DEC 23 1983 A

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The U.S. Army Engineer Topographic Laboratories (USAETL) is responsible for Army research and development in the areas of mapping and terrain analysis. In general this involves methods, techniques, and systems for information processing related to the extraction, analysis, and presentation of terrain data. Typically, the data source is aerial imagery and the real-world information processing techniques for aerial imagery are very labor intensive. Previous research into automated techniques has not yielded results adequate to justify significant equipment developments necessary for future Army Terrain information processing requirements.

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

Thus, USAETL is making a significant commitment in AI with expectations for new and improved terrain information processing capabilities for the Army.

The following discussion will relate to the AI research environment at USAETL. This includes the rationale for the USAETL AI program, the objectives and approach of the Center for Artificial Intelligence (CAI), a description of the CAI AI facilities, and a brief description of the current CAI research program.

THE AI RESEARCH ENVIRONMENT AT THE U.S. ARMY ENGINEER TOPOGRAPHIC LABORATORIES

Robert D. Leighty
Research Institute, USAETL
Fort Belvoir, VA 22060

ABSTRACT

The U.S. Army Engineer Topographic Laboratories (USAETL) is responsible for Army research and development in the areas of mapping and terrain analysis. In general, this involves methods, techniques, and systems for information processing related to the extraction, analysis, and presentation of terrain data. Typically, the data source is aerial imagery and the real-world information processing techniques for aerial imagery are very labor-intensive. Previous research into automated techniques has not yielded results adequate to justify significant equipment developments necessary for future Army terrain information processing requirements. Thus, USAETL is making a significant commitment in AI with expectations for new and improved terrain information processing capabilities for the Army.

This paper discusses ~~The following discussion will relate to~~ the artificial intelligence ~~AI~~ research environment at USAETL. This includes the rationale for the USAETL AI program, the objectives and approach of the Center for Artificial Intelligence (CAI), a description of the CAI AI facilities, and a brief description of the current CAI research program.

RATIONALE FOR USAETL AI PROGRAM

USAETL Mission

USAETL has, as a portion of its mission, responsibilities to accomplish research and development for the Field Army and the Defense Mapping Agency (DMA) in the areas of topographic mapping and terrain analysis. In general, the basic source of data for this work is aerial imagery. The basic problem associated with this data type is cost effective and timely extraction of information for the various tasks of the mapping and terrain analysis processes. Conventional approaches to this problem area involve manual methods which are excessively labor intensive and time consuming. Future goals relate to automated systems necessary to address an increasing number of requirements for terrain data in military information and weapon systems.

Automated Pattern Recognition Research At USAETL

USAETL researchers have actively pursued automated extraction of information from aerial imagery with statistical pattern recognition techniques since the 1960's with only limited progress in selected areas. These techniques have not been sufficiently robust or general to justify operational system development. Clearly, new approaches are needed for old problems as well as the new problems associated with digital terrain information processing for the Army of the future.

DARPA Image Understanding Program

In the mid-1970s USAETL began tracking the Defense Advanced Research Project Agency (DARPA) program in Image Understanding. In this program the Information Processing Techniques Office, DARPA, has contracted with artificial intelligence groups at universities such as MIT, Carnegie-Mellon University, Stanford University, University of Rochester, University of Maryland, Purdue University, University of Southern California, and SRI International (SRI), to investigate methods, techniques, and systems leading to useful automated machine vision capabilities. In the late 1970s DARPA began to focus its Image Understanding program on application areas and one application area was "cartography." The objective in this research area involved the extraction of information from aerial images for mapping purposes. For this effort, DARPA realigned a significant portion of its Image Understanding program to (1) attack fundamental problems in computer vision relevant to cartography and photo interpretation and (2) design and implement a testbed facility at SRI which would integrate software contributions from the Image Understanding contractors. In 1979, USAETL assumed the role as DARPA's agent for the DARPA/DMA Cartographic Testbed.

USAETL Commitment to AI

USAETL began its commitment to AI in February 1981 with a decision to acquire a duplicate of the DARPA/DMA Cartographic Testbed for in-house R&D programs. The rationale for this decision came from the need for improved techniques for information extraction from aerial imagery. It was reasoned that automated statistical pattern recognition approaches, with which USAETL researchers had considerable experience, would be needed in AI systems to generate symbols from image data. It was realized that the organization lacked AI programming expertise, however, through a proper mix of training, contracts, and new hires this capability could be developed over a period of time. Further, it was recognized that USAETL had experts in terrain analysis and automated cartography necessary for building knowledge-based systems. And perhaps more significant, the cartographic and terrain data bases common to the mapping community could be employed in AI techniques to guide image information extraction processes.

CAI was established within the Research Institute in August 1982. The objectives of CAI are to conduct basic and applied research in artificial intelligence methods and techniques leading to semi-autonomous and autonomous systems of the future in support of USAETL mission areas.

USAETL Commitment to Army AI/Robotics

In March 1981, USAETL was requested by Deputy Chief of Staff Research, Development, and Acquisition (DCSRDA) to prepare a baseline Army R&D plan for AI/Robotics leading to techniques and systems to assist combat and combat support personnel in battlefield missions. Under a competitively awarded contract, SRI

prepared and published a study report in May 1982 containing a suggested Army R&D plan. In July 1981, due to mounting interest in AI/Robotics within Army Headquarters, a DCSRDA Steering Committee for AI/Robotics was formed. This Committee contained representatives from Office of the Chief of Engineers (USAETL), Deputy Chief of Staff for Personnel (Army Research Institute for Behavioral and Social Sciences), DARCOM (Human Engineering Laboratory), The Surgeon General, and TRADOC and it opted to initiate an Army AI/Robotics Program. More than 100 applications of AI/Robotics systems to Army activities were prioritized by TRADOC Schools and Centers. Subsequent guidance from Army Headquarters was to concentrate on a small number of applications. This led to the Steering Committee selection of of five "Demonstrators." USAETL prepared a plan for the Robotic Reconnaissance Vehicle with Terrain Analysis and this was combined with a Human Engineer Laboratory (HEL) plan. The objective of this demonstrator is to demonstrate, in two years after funding, the capability to plan and conduct teleoperated reconnaissance vehicle operations for representative battlefield missions. This plan was given top priority by TRADOC and an Army Science Board Ad Hoc Subgroup for AI/Robotics and has been funded for FY84 and FY85. USAETL will have responsibility for the hardware and software systems and HEL will be responsibility for the demonstration scenerio and the conduct of the demonstration.

THE CAI APPROACH

Objectives

To repeat, the objectives of CAI are to conduct basic and applied research in AI methods and techniques leading to semi-autonomous and autonomous systems of the future in support of USAETL mission areas. This implies that research will be conducted not only in information extraction from aerial imagery and autonomous vehicle systems within CAI, but also in support of the total USAETL R&D program, which includes Field Army, DMA, and Civil Works, as well as other USAETL customers.

Personnel

CAI currently has 13 professionals with technical backgrounds that include civil and electrical engineers, computer scientists, cartographers, geologists, foresters, and physicists. While all have advanced degrees, none have formal AI training above the master's degree, thus retraining has a very high priority in CAI. The retraining will be available in several forms: long term, formal training at universities; part time, formal training at universities; AI short courses; TV lecture series; in-house contractor training; professional meetings; and self learning on the in-house software/hardware systems.

CAI Facilities

USAETL will, by the end of FY83, have excellent AI facilities. The principal element of the Testbed hardware configuration is a DEC VAX-11/780 central processing unit. The VAX is a four-megabyte system with one tape drive, two 300-megabyte disc drives, 16 teletype lines, floating point accelerator, and parallel DMA interface. The VAX interfaces directly to a variety of terminals, a digitizing table, a menu tablet, a Grinnell display system, a Versatec

printer/plotter, and an Optronics color image scanner. A Symbolics Model 3600 LISP machine will be connected to the VAX system by an ETHERNET, as will other computer systems in CAI mentioned below. (Mention of commercially available equipment is not an endorcement of this equipment.)

CAI will have a number of software packages available for experimentation. To be of value, these must be tested and evaluated for potential use to the CAI program. The AI Testbed software from SRI will be thoroughly exercised so as to provide an effective interface between DMA and the DARPA Image Understanding Program. Other AI software packages, such as OPS5 and KES, will be available. By exercising the programs available with typical USAETL data, strengths and weaknesses of existing software will serve as the basis for the subsequent research program and acquisition of other software/hardware.

Approach

Most of the CAI effort for FY83 will be devoted to an on-going research program, training, testing of existing software packages, and tracking-related AI activities of other organizations. The on-going research program, which includes Computer-Assisted Photo Interpretation Research (CAPIR), AI/Robotics, etc., will be discussed subsequently. Training will consist of the formal and informal instruction indicated above. Additionally, training exercises will be developed for small teams within CAI to serve as mechanisms to focus training activities. An example will be given subsequently. Efforts will be devoted to testing the DARPA/DMA Testbed software as well as other available software. Finally, related AI efforts of other governmental agencies will be tracked.

In FY84 CAI will begin to integrate AI into the on-going research program and develop a program which applies the DARPA/DMA Testbed capability to USAETL mission areas. The Army AI/Robotics Reconnaissance Vehicle Demonstrator will be funded and involve CAI in the demonstration and initiation of research leading to the autonomous vehicle.

CAI RESEARCH PROGRAM

Major elements of the FY83 on-going CAI research program will now be outlined. These efforts are in addition to other activities indicated above dealing with training and software testing.

Computer-Assisted Landform Analysis Program - CALAP

Operational terrain analysis from aerial imagery is labor intensive and requires expert terrain analysts. CAI has a research effort directed toward developing an interactive computer program that may be used to lead a relatively inexperienced photo interpreter through a landform analysis problem for any study area in a selected physiographic region.

CALAP conducts an interactive diagnostic dialogue with the interpreter and serves as a computer expert assistant. It operates analogous to a blind expert sitting with the interpreter. CALAP is based on the principles of physiography and geomorphology. The world is divisible into physiographic units and physiographic units can be divided into local areas based upon landform types. Any given

physiographic unit contains only a small subset of the total landforms found in the world. Thus, if one is given the location of the aerial images to be studied, the physiographic unit containing this location is defined as well as an expected set of landforms to be found in that unit. The recognition diagnostics are then constrained to this expected set of landforms. In the analysis procedure the interpreter is prompted to look for and report terrain patterns. For example, if the study area is located in the Atlantic Coastal Plain he may be asked if a coastal shoreline exists in the study area. If so, this will indicate the possibility for coastal beaches, beach ridges and swales, sand dunes, etc., and after their characteristics are defined for the interpreter, the area adjacent to the shoreline is then searched for the expected set of landforms. The analysis would then move sequentially through decision trees associated with locating and delineating landforms expected to be found in association with tidal river basins, recent alluvium, and coastal plain terraces.

The CALAP program is presently written in FORTRAN and operates on a Hewlett Packard 1000/F-series minicomputer. The program has been recoded into OPS5 running in FRANZLISP on a DEC VAX 11/780 as a possible training aid in which FORTRAN and FRANZLISP code can be directly compared. While this is instructive for the novice LISP programmer, the one-to-one recoding yields a less efficient LISP operating program.

Computer-Assisted Photo Interpretation Research - CAPIR

An in-house laboratory system has been designed, developed and used to support research studies and demonstrations of computer-assisted photo interpretation. This is called the CAPIR system. The focal point of the CAPIR system is a stereoscopic workstation incorporating an APPS-IV analytical plotter with graphic superposition, an integral voice recognition module, and two large application programs which support creation of geographic data bases directly from stereo images and manipulation and statistical analysis of the geographic data bases. The CAPIR system also incorporates a Data General Eclipse S/250 minicomputer with an Integral Array Processor and standard peripheral devices such as discs, magnetic tape drives, printers, and CRT display terminals.

CAPIR embodies three basic concepts: (1) direct data entry in a geographic coordinate system to digital files; (2) on-line stereodigitization using a computer-interfaced stereoscope; and (3) direct superposition of computer generated graphics in the stereomodel. Thus, points, lines and areas with three-dimensional ground coordinates can be entered into the data bases and displayed in the working stereo images. Direct superposition provides a means to review, edit, and/or verify on-going or previously prepared digital data bases for the terrain areas covered by the stereo images. Solid-state CID cameras have been added to each optical channel of the stereoscope to enable subsequent computer processing of the image under study by the photo interpreter. These capabilities, when interfaced to the AI Testbed, will provide the basis for an evolutional image analysis capability leading to a system with a high degree of autonomy.

The CAPIR is presently an operational image analysis system with a manual capability for building terrain data bases. Integrating AI knowledge-based expert modules for location and delineation of landforms, drainage, vegetation, cultural patterns, etc., will provide growing capabilities for semi-automated image

analysis. For example, an interpreter analyzing stereo images of an area might invoke an automated vegetation classifier by a voice command. This will cause the digital images to be sampled by the CID cameras and operated on by the vegetation expert software in the AI Testbed. The expert system would use existing information in the terrain or cartographic data bases to guide the digital area search and classification processes. Results are then displayed to the interpreter via the graphic superposition for his verification and/or edit. As more of the AI modules are added and as they get smarter (requiring less human intervention), the system will evolve to a semi-automated image analysis system. CAI is currently working on the next generation CAPIR involving a softcopy stereoscope.

Robotics

USAETL is interested in R&D leading to autonomous vehicle navigation in a battlefield environment. In the first stage of this effort, a vehicle will be teleoperated by non-line-of-sight communications from a control van. The vehicle will have a position/navigation inertial sensor, stereo cameras, and communication equipment on-board. In the control van, super microcomputers will process and display the stereo images to the vehicle controller and plot the position of the remote vehicle as a blinking cursor on a graphics map background of another display. This map display will be used to plan and then operate the vehicle along a route selected by the computer and verified/edited by the operator. The route planner (expert system) will use digital terrain data bases to compute the best route between terminal and/or intermediate points for the route and the route is then displayed, along with the vehicle cursor, on the map display. Another display will be used for supplementary graphics that serve to provide the vehicle operator with additional information about the vehicle position in its surroundings. For example, this display could image digitally computed isometric images of the operational area with the vehicle plotted in proper position. It could show computer-generated images at points along the route where operator decisions are critical. Thus, turning points, change in slopes, and bridge or stream crossings are examples of critical points along the intended route that might have associated computer-generated images with which the operator can compare to the real-time stereo images and make steering adjustments if required. If the operator encounters difficulty not anticipated from the prior route planning, he can reenter the planning mode to navigate around the obstacle.

This is essentially the terrain navigation section of the Robotic Reconnaissance Vehicle Demonstrator, mentioned above, that is due to be demonstrated in late FY85. The long-term objective of the Demonstrator is to transform the human planning and system operating capabilities from the control van to the vehicle. The vehicle would then have responsibility to plan its route from internal terrain data bases and navigate along this planned route with the aid of machine vision and local steering control. The vehicle will require smarts to recognize obstacles and plan alternate routes to the objective. The human supervisor would be needed only to assign missions, infrequently oversee operations, and be available to handle decisions and operations out of the range of the vehicle's potential.

Other Research Activities

There are two other smaller efforts requiring some mention. The first deals with a capability for automated delineation of drainage patterns from

digital terrain elevation data and the second deals with building a prototype battlefield intelligence expert system that incorporates terrain data.

The drainage expert system is motivated from the need to make present labor-intensive manual cartographic processes of topographic drainage delineation for mapping purposes more efficient. Manual techniques require an operator to annotate topographic gullies under stereoscopic viewing conditions, often after terrain elevation data has been extracted for mapping purposes from the same area. Algorithms have been tested for application to drainage delineation from the digital elevation data. These will be incorporated into an expert system that will handle algorithm scheduling and control and integrate simple heuristics to operate in special case situations. This study will be done in the CAPIR environment with graphic superposition of delineated drainage directly into the stereomodel for operator verification/edit.

The battlefield intelligence expert system is a cooperative study between CAI and the U.S. Army Intelligence School and Center (USAICS) and is used by CAI to focus AI training and software testing activities. USAICS personnel will serve as the domain experts for the military intelligence and sensor management knowledge base building and CAI will serve as the AI experts to acquire and represent the knowledge in expert system form. The problem is associated with Intelligence Preparation of the Battlefield (IPB) and intelligence collection resource management. For an enemy area wherein we have knowledge of troop and equipment distribution and special areas of the terrain through which enemy units must pass to attack friendly positions, we are given some information about activity in one or more of the special areas. A hypothesis is then formed as to the nature of the activity and an optimum available sensor is selected and scheduled to acquire intelligence related to the hypothesis. The sequence of hypothesis and test leads to a conclusion of the enemy intent. This study has just begun and it is intended that available expert system building software such as OPS5, ROSIE, or EMICIN will be used to test concepts.

SUMMARY

USAETL is making a commitment to AI research with the expectation that new and more efficient methods and techniques may be applied to the solution of old problems in its mission areas as well as the new problems associated with digital terrain information processing for the Army of the future. This commitment has involved allocation of technology based funds for equipping a state-of-the-art AI research facility and establishment of a research group (CAI) with a charter to investigate AI for applications within its mission areas. Additionally, a research budget and personnel have been assigned to AI research and start-up time is being provided for personnel training. On-going USAETL AI research efforts generally employ interactive (man-in-the-loop) approaches wherein AI modules are expected to provide efficient enhancements in an evolutional manner rather than targeting upon specific AI-aided systems to be produced some years in the future.

This is the essence of the AI research environment at the U.S. Army Engineer Topographic Laboratories.

DATE
FILMED
8